

Techdata Sheet



*TDS-2004-ENG
March 1994*

NAVAL FACILITIES ENGINEERING SERVICE CENTER PORT HUENEME, CA 93043-4328

Geothermal Heat Pumps for Heating and Cooling

BACKGROUND

A large part of a building's energy consumption consists of heating and air conditioning for occupant comfort. The space heating requirements are normally met by fossil-fuel-fired equipment or electric resistance heating. Cooling is provided by either air conditioners or heat pumps, both using electricity as an energy source. In temperate climates, air-source heat pumps (ASHP) can be used for both heating and cooling, but they are not feasible in cold regions. Water-source heat pumps could provide a more energy-efficient and cost-effective means of providing space heating and cooling in both cold regions and more temperate climates. In areas where groundwater sources are not available or economically feasible, a geothermal heat pump (also called ground-coupled or ground-source heat pump) (GHP) is an alternative. GHPs exchange heat with the ground using a closed, plastic piping loop. Because of the relatively stable ground temperature, it is a favorable energy source and sink for heat pumps. This is especially true when compared to outdoor air that becomes a poor heat source or sink coincident with the highest demand.

GEO THERMAL HEAT PUMPS

Heat normally flows from hot to cold. Similar to the operation of a refrigerator, "pumping" of heat from a colder to a warmer area requires expenditure of energy. During the winter months, a heat pump transfers heat from the outdoor air or ground to a building, whereas during the summer it transfers heat from the building to the outside air or ground. Obviously, a higher temperature source is more efficient for heating and a lower temperature sink is more favorable for cooling. Therefore, when compared to the outdoor air, the ground provides a much better source and sink in most all cases.

To sum up, GHPs are superior when compared with ASHPs for three reasons:

1. The soil acts as a storage device for the thermal energy rejected from a building during the summer months, which is then made available for heating the building during the early part of the heating season. The opposite takes place during the summer months.

2. A few feet below the surface, the soil temperature is largely unaffected by the outside air temperature. The GHPs, therefore, extract thermal energy during the winter months from soil that is much warmer than the outside air. Similarly, GHPs reject thermal energy during the summer months to the soil that is much cooler than the outside air.

3. GHPs can be used even in very cold climates where ASHPs are either completely unsuitable or require switching to resistance heating during very cold conditions.

Experience in the private sector has shown GHPs can reduce electrical energy consumption by 20 to 30 percent cost effectively compared to the ASHPs. If the GHPs' expected reduction in the amount of repair and maintenance required is also taken into account, then GHPs become even more attractive. Advantages of using GHPs are:

- Because of their higher efficiency, GHPs reduce peak electrical demand below the level of ASHPs, thereby reducing the electric bill.
- GHPs have closed ground loops (consisting of plastic piping) that do not circulate refrigerant between the indoor and the outdoor equipment, reducing the potential for a leak into the environment.
- GHP equipment are located inside the building, which protects them from environmental exposure, increasing their useful life.
- Due to reduced operating temperature range, the useful life of the GHP's compressors is higher than ASHP compressors.
- GHPs require far less maintenance compared to other alternatives.

GHPs are being extensively used in the private sector to replace resistance heating, propane, and even natural gas in very cold climates, i.e., in regions where ASHPs are not suitable. Studies conducted by the U.S. Environmental Protection Agency (EPA) have found GHPs to be energy-efficient and cost-effective, and protect the environment. GHPs have also been recommended by the Department of Energy (DOE) as an efficient energy-conserving alternative for building heating and cooling.

CURRENT GHP USE WITHIN THE DEPARTMENT OF DEFENSE

A field test and evaluation (T&E) program carried out by the Army, was partially funded by DOE under their Strategic Environmental Research & Development Program (SERDP). This demonstration program was to prove the cost-effectiveness of GHPs when operating in a military environment. The test and evaluation is ongoing at Fort Polk, LA. In this T&E program, the GHPs provide heat and air conditioning for five housing units and their performance is compared with the ASHP units used in five identical housing units. Results to date show reduction in electrical consumption by GHPs by about 20 percent when compared with the ASHPs. In addition, these GHPs have required very little repair and maintenance.

This successful T&E of GHPs has convinced Fort Polk to award a contract converting the remaining heating and cooling systems in 4,000+ housing units to GHPs. This contract is based on shared energy savings; i.e., the contractor will pay for and own all 4,000+ GHPs, and gets paid 80 percent of the savings in energy and maintenance costs (the Army keeps 20 percent of the savings).

In the Navy, the Naval Air Station (NAS) at Patuxent River, MD, is extensively renovating two buildings. Building 114, a 6,200 ft², 3-story building, is scheduled to be equipped with three, 5-ton GHPs. The second building is the 38,400 ft² Frank Knox School. This building, along with

the nearby guard house, will be heated and air conditioned by 18 GHP units ranging in size between 4- and 14-ton capacity. Each GHP unit will operate independently of other GHP units and condition its assigned space. Both buildings are scheduled to become operational by the end of FY94.

Naval Facilities Engineering Services Center (NFESC) has been tasked by Naval Shore Facilities Energy Office to evaluate the NAS Patuxent River GHPs installation. The purpose of this task is also to turn this GHP installation into a demonstration project within the Navy community to

show the effectiveness of GHPs in reducing O&M costs incurred by the Navy in providing heating and cooling for buildings. NFESC's evaluation will consist of establishing the overall energy savings achieved by these GHPs as well their life-cycle cost effectiveness. Detailed information will be gathered on repair and maintenance requirements of these GHPs. This evaluation is being partially funded by DOE under the SERDP program. This project is planned to continued as a joint Navy-DOE demonstration effort.

NFESC has disseminated three, 2-hour videotapes of conferences on GHPs, sponsored by DOE, to the Navy's EFDs. If any other Navy organization would like to see these videotapes, please either contact your EFD or:

Dr. Suresh C. Garg, Code ESC21
Energy & Utilities Development Division
Naval Facilities Engineering Service Center
Port Hueneme, CA 93043-4328
Phone: (805) 982-1325; DSN 551-1325
FAX (805) 982-5388; DSN 551-5388

Others are welcome to contact:

Dr. William N. Sullivan, ORG 6111
Sandia National Laboratory
Albuquerque, NM 87185
Phone: (505) 844-3354; FAX (505) 844-3952

DEPARTMENT OF THE NAVY

COMMANDING OFFICER

NFESC

560 CENTER DRIVE

PORT HUENEME CA 93043-4328

OFFICIAL BUSINESS

NFESC 5110/1 (10/93)